

# Report of the 14<sup>th</sup> Session of the IOTC Working Party on Methods (Management Strategy Evaluation Task Force)

Online, 28 - 31 March 2023

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**BIBLIOGRAPHIC ENTRY**

IOTC–WPM14(MSE) 2023. Report of the 14<sup>th</sup> Session of  
the IOTC Working Party on Methods (MSE Task Force).  
Online 28-31 March 2023. *IOTC–2023–WPM14(MSE)–  
R[E]*: 23 pp.

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## ACRONYMS

ABNJ	Areas Beyond National Jurisdiction
ALB	Albacore
B	Biomass (total)
B <sub>0</sub>	Unfished biomass
BET	Bigeye tuna
B <sub>MSY</sub>	Biomass which produces MSY
CMM	Conservation and Management Measure (of the IOTC; Resolutions and Recommendations)
CPCs	Contracting parties and cooperating non-contracting parties
CPUE	Catch per unit of effort
current	Current period/time, i.e. F <sub>current</sub> means fishing mortality for the current assessment year.
F	Fishing mortality
FAD	Fish aggregating device
F <sub>MSY</sub>	Fishing mortality at MSY
IOTC	Indian Ocean Tuna Commission
MP	Management Procedure
MPD	Management Procedures Dialogue
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
OM	Operating Model
P	Probability
SC	Scientific Committee, of the IOTC
SB	Spawning biomass (sometimes expressed as SSB)
SB <sub>MSY</sub>	Spawning stock biomass which produces MSY (sometimes expressed as SSB <sub>MSY</sub> )
TCMP	Technical Committee on Management Procedures
WPM	Working Party on Methods
WPNT	Working Party on Neritic Tunas
WPTT	Working Party on Tropical Tunas of the IOTC
YFT	Yellowfin tuna

## GLOSSARY OF TERMS

The WPM decided to utilise the MSE Glossary developed by the Joint Tuna RFMO MSE Working Group in 2018.

**Average Annual Variation** - (in catch/TAC) The absolute value of the proportional TAC change each year, averaged over the projection period.

**Biomass** - Stock biomass, which may refer to various components of the stock. Often spawning stock biomass (SSB) of females is used, as the greatest conservation concern is to maintain the reproductive component of the resource.

**Candidate Management Procedure** - An MP (defined below) that has been proposed, but not yet adopted.

**Conditioning** - The process of fitting an Operating Model (OM) of the resource dynamics to the available data on the basis of some statistical criterion, such as a Maximum Likelihood. The aim of conditioning is to select those OM's consistent with the data and reject OM's that do not fit these data satisfactorily and, as such, are considered implausible.

**Error** - Differences, primarily reflecting uncertainties in the relationship between the actual dynamics of the resource (described by the OM's) and observations. Four types of error may be distinguished, and simulation trials may take account of one or more of these:

- Estimation error: differences between the actual values of the parameters of the OM and those provided by the estimator when fitting a model to the available data;
- Implementation error: differences between intended management actions (as output by an MP) and those actually achieved (e.g. reflecting over-catch);
- Observation error (or measurement error): differences between the measured value of some resource index and the corresponding value calculated by the OM;
- Process error: natural variations in resource dynamics (e.g., fluctuations about a stock-recruitment curve or variation in fishery or survey selectivity /catchability).

**Estimator** - The statistical estimation process within a population model (assessment or OM); in a Management Strategy Evaluation (MSE) context, the component that provides information on resource status and

productivity from past and generated future resource-monitoring data for input to the Harvest Control Rule (HCR) component of an MP in projections.

**Exceptional circumstances** - Specifications of circumstances (primarily related to future monitoring data falling outside the range covered by simulation testing) where overriding of the output from a Management Procedure should be considered, together with broad principles to govern the action to take in such an event.

**Feedback Control** - Rules or algorithms based, directly or indirectly, on trends in observations of resource indices, which adjust the management actions (such as a TAC change) in directions that will change resource abundance towards a level consistent with decision makers' objectives.

**Harvest Control Rule** - (also Decision Rule) A pre-agreed and well-defined rule or action(s) that describes how management should adjust management measures in response to the state of specified indicator(s) of stock status. This is described by a mathematical formula.

**Harvest Strategy** - Some combination of monitoring, assessment, harvest control rule and management action designed to meet the stated objectives of a fishery. Sometimes referred to as a Management Strategy (see below). A fully specified harvest strategy that has been simulation tested for performance and adequate robustness to uncertainties is often referred to as a Management Procedure.

**Implementation** - The practical application of a Harvest Strategy to provide a resource management recommendation.

**Kobe Plot** - A plot that shows the current stock status, or a trajectory over time for a fished population, with abundance on the horizontal axis and fishing mortality on the vertical axis. These are often shown relative to BMSY and to FMSY, respectively. A Kobe plot is often divided into four quadrants by a vertical line at  $B=B_{MSY}$  and a horizontal line at  $F=F_{MSY}$ .

**Limit Reference Point** - A level of biomass below, or fishing mortality above, which an actual value would be considered undesirable, and which management action should seek to avoid.

**Management Objectives** - The social, economic, biological, ecosystem, and political (or other) goals for a given management unit (i.e. stock). These typically conflict, and include concepts such as maximising catches over time, minimising the chance of unintended stock depletion, and enhancing industry stability through low inter-annual variability in catches. For the purposes of Management Strategy Evaluation (MSE) these objective need to be quantified in the form of Performance statistics (see below).

**Management Plan** - In a broad fisheries governance context, a Management Plan is the combination of policies, regulations and management approaches adopted by the management authority to reach established societal objectives. The management plan generally includes the combination of policy principles and forms of management measures, monitoring and compliance that will be used to regulate the fishery, such as the nature of access rights, allocation of resources to stakeholders, controls on inputs (e.g. fishing capacity, gear regulations), outputs (e.g. quotas, minimum size at landing), and fishing operations restrictions (e.g. closed areas and seasons). Ideally, the Management Plan will also include the Harvest Strategy for the fishery or a set of principles and guidelines for the specification, implementation and review of a formal Management Procedure for target and non-target species.

**Management Procedure** - A management procedure has the same components as a harvest strategy. The distinction is that each component of a Management Procedure is formally specified, and the combination of monitoring data, analysis method, harvest control rule and management measure has been simulation tested to demonstrate adequately robust performance in the face of plausible uncertainties about stock and fishery dynamics.

**Management Strategy** - Synonymous with harvest strategy. (But note that this is also used with a broader meaning in a range of other contexts.)

**Management Strategy Evaluation** - A process whereby the performances of alternative harvest strategies are tested and compared using stochastic simulations of stock and fishery dynamics against a set of performance statistics developed to quantify the attainment of management objectives.

**Maximum Economic Yield** - The (typically annual) yield that can be taken continuously from a stock sustainably (i.e. without reducing its size) that maximizes the economic yield of a fishery in equilibrium. This yield occurs at the effort level that creates the largest positive difference between total revenues and total costs of fishing (including the cost of labor, capital, management and research etc.), thus maximizing profits.

**Maximum Sustainable Yield** - The largest (typically annual) yield that can be taken continuously from a stock sustainably (i.e. without reducing its size). In real, and consequently stochastic situations, this is usually estimated as the largest average long-term yield that can be obtained by applying a constant fishing mortality  $F$ , where that  $F$  is denoted as  $F_{MSY}$ .

**Observation Model** - The component of the OM that generates fishery-dependent and/or fishery-independent resource monitoring data from the underlying true status of the resource provided by the OM, for input to an MP.

- Operating Model(s)** - A mathematical–statistical model (usually models) used to describe the fishery dynamics in simulation trials, including the specifications for generating simulated resource monitoring data when projecting forward in time. Multiple models will usually be considered to reflect the uncertainties about the dynamics of the resource and fishery.
- Performance statistics/measures** - A set of statistics used to evaluate the performance of Candidate MPs (CMPs) against specified management objectives, and the robustness of these MPs to important uncertainties in resource and fishery dynamics.
- Plausibility (weights)** - The likelihood of a scenario considered in simulation trials representing reality, relative to other scenarios also under consideration. Plausibility may be estimated formally based on some statistical approach, or specified based on expert judgement, and can be used to weight performance statistics when integrating over results for different scenarios (OMs).
- Precautionary Approach** - An approach to resource management in which, where there are threats of serious irreversible environmental damage, lack of full scientific certainty is not used as a reason for postponing cost-effective measures to prevent environmental degradation.
- Reference case** - (also termed reference scenario or base case) A single, typically central, conditioned OM for evaluating Candidate MPs (CMPs) that provides a pragmatic basis for comparison of performance statistics of the CMPs.
- Reference set** - (also termed base-case or evaluation scenarios) A limited set of scenarios, with their associated conditioned OMs, which include the most important uncertainties in the model structure, parameters, and data (i.e. alternative scenarios which have both high plausibility and major impacts on performance statistics of Candidate MPs).
- Research-conditional option** - Temporary application of an MP that does not satisfy conservation performance criteria, accompanied by both a research programme to check the plausibility of the scenarios that gave rise to this poor performance and an agreed subsequent reduction in catches should the research prove unable to demonstrate implausibility.
- Robustness tests** - Tests to examine the performance of an MP across a full range (i.e. beyond the range of the Reference Set of models alone) of plausible scenarios. While plausible, robustness test OMs are typically considered to be less likely than the reference set OMs, and often focus on particularly challenging circumstances with potentially negative consequences to be avoided.
- Scenario** - A hypothesis concerning resource status and dynamics or fishery operations, represented mathematically as an OM.
- Simulation trial/test** - A computer simulation to project stock and fishery dynamics for a particular scenario forward for a specified period, under controls specified by a HS or MP, to ascertain the performance of that HS or MP. Such projections will typically be repeated a large number of times to capture stochasticity.
- Spawning Biomass, initial** - Initial spawning biomass prior to fishing as estimated from a stock assessment.
- Spawning Biomass, current** - Spawning biomass (SSB) in the last year(s) of the stock assessment.
- Spawning Biomass at MSY** - The equilibrium spawning biomass that results from fishing at FMSY. In the presence of recruitment variability, fishing a stock at FMSY will result in a biomass that fluctuates above and below SSB<sub>MSY</sub>.
- Stationarity** - The assumption that population parameter values are fixed (at least in expectation), and not varying systematically, over time. This is a standard assumption for many aspects of stock assessments, OMs and management plans.
- Stock assessment** - The process of estimating stock abundance and the impact of fishing on the stock, similar in many respects to the process of conditioning OMs.
- Target Reference Point** - The point which corresponds to a state of a fishery and/or resource which is considered desirable and which management aims to achieve.
- Trade-offs** - A balance, or compromise, achieved between desirable but conflicting objectives when evaluating alternative MPs. Trade-offs arise because of the multiple objectives in fisheries management and the fact that some objectives conflict (e.g. maximizing catch vs minimizing risk of unintended depletion).
- Tuning** - The process of adjusting values of control parameters of the Harvest Control Rule in a Management Procedure to achieve a single, precisely-defined performance statistic in a specified simulation test. This reduces confounding effects to allow the performance of different candidate MPs to be compared more readily with respect to other management objectives. For example, in the case of evaluating rebuilding plans, all candidate MPs might be tuned to meet the rebuilding objective for a specified simulation trial; then the focus of comparisons among MPs is performance and behaviour with respect to catch and CPUE dimensions.
- Weight(s)** - Either qualitative (e.g. high, medium, low) or quantitative measures of relative plausibility accorded across a set of scenarios.

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**Worm plot** - Time series plots showing a number of possible realizations of simulated projections of, for example, catch or spawning biomass under the application of an MP for a specific OM or weighted set of OMs.

## STANDARDISATION OF IOTC WORKING PARTY AND SCIENTIFIC COMMITTEE REPORT TERMINOLOGY

SC16.07 (para. 23) The SC **ADOPTED** the reporting terminology contained in Appendix IV and **RECOMMENDED** that the Commission considers adopting the standardised IOTC Report terminology, to further improve the clarity of information sharing from, and among its subsidiary bodies.

### HOW TO INTERPRET TERMINOLOGY CONTAINED IN THIS REPORT

**Level 1:** *From a subsidiary body of the Commission to the next level in the structure of the Commission:*

**RECOMMENDED, RECOMMENDATION:** Any conclusion or request for an action to be undertaken, from a subsidiary body of the Commission (Committee or Working Party), which is to be formally provided to the next level in the structure of the Commission for its consideration/endorsement (e.g. from a Working Party to the Scientific Committee; from a Committee to the Commission). The intention is that the higher body will consider the recommended action for endorsement under its own mandate, if the subsidiary body does not already have the required mandate. Ideally this should be task specific and contain a timeframe for completion.

**Level 2:** *From a subsidiary body of the Commission to a CPC, the IOTC Secretariat, or other body (not the Commission) to carry out a specified task:*

**REQUESTED:** This term should only be used by a subsidiary body of the Commission if it does not wish to have the request formally adopted/endorsed by the next level in the structure of the Commission. For example, if a Committee wishes to seek additional input from a CPC on a particular topic, but does not wish to formalise the request beyond the mandate of the Committee, it may request that a set action be undertaken. Ideally this should be task specific and contain a timeframe for the completion.

**Level 3:** *General terms to be used for consistency:*

**AGREED:** Any point of discussion from a meeting which the IOTC body considers to be an agreed course of action covered by its mandate, which has not already been dealt with under Level 1 or level 2 above; a general point of agreement among delegations/participants of a meeting which does not need to be considered/adopted by the next level in the Commission's structure.

**NOTED/NOTING:** Any point of discussion from a meeting which the IOTC body considers to be important enough to record in a meeting report for future reference.

**Any other term:** Any other term may be used in addition to the Level 3 terms to highlight to the reader of an IOTC report, the importance of the relevant paragraph. However, other terms used are considered for explanatory/informational purposes only and shall have no higher rating within the reporting terminology hierarchy than Level 3, described above (e.g. **CONSIDERED; URGED; ACKNOWLEDGED**).

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**EXECUTIVE SUMMARY**

The 14<sup>th</sup> Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Methods Management Strategy Evaluation Task Force (WPM(MSE)) was held online using Zoom from 28 - 31 March 2023. A total of 31 participants attended the Session. The list of participants is provided in [Appendix I](#). The meeting was opened by the Chairperson, Dr Hilario Murua (ISSF) who welcomed participants.

The following are the recommendations from the WPM14 to the Scientific Committee, and key outcomes of the WPM, which are provided in [Appendix V](#)

WPM(MSE)14.01: The WPM(MSE) **NOTED** the Commission's inclusion of an additional TCMP meeting early each year, and although this additional session of the TCMP has not taken place in 2023 (see paragraph 9 below), it **RECOMMENDED** that it would be necessary in 2024 to present the final advice regarding SKJ for the Commissions consideration (Para 6).

## 1. OPENING AND ADOPTION OF AGENDA

1. The 14<sup>th</sup> Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Methods Management Strategy Evaluation Task Force (WPM(MSE)) was held online using Zoom from 28-31 March 2023. A total of 31 participants attended the Session. The list of participants is provided in Appendix I. The meeting was opened by the Chairperson, Dr Hilario Murua (ISSF) who welcomed participants.
2. The WPM(MSE) **ADOPTED** the Agenda provided at Appendix II. The documents presented to the WPM(MSE) are listed in Appendix III.

## 2. REVIEW OF MP PROCESS IN IOTC

### 2.1 Review outcomes of TCMP05 and COM (S26) in 2022

3. The WPM **NOTED** a presentation by the Chair regarding the updates from the 2022 Session of the Commission (S26) as well as a recap of the deliberations during the 2022 TCMP05. The presentation summarised the information related to MSE found in documents IOTC-2022-TCMP05-R and IOTC-2022-S26-R.
4. The WPM(MSE) **NOTED** the Commission Adoption of Resolution 22/03 *On a Management Procedure for Bigeye Tuna in the IOTC Area of Competence*. The WPM(MSE) congratulated all involved (and in particular the developers at CSIRO) in providing the technical advice that underpinned the adopted Resolution.
5. The WPM(MSE) were **INFORMED** that in the Commission report (IOTC-2022-S26-R):
 

*“(Para 46 2<sup>nd</sup> bullet point) The TCMP **NOTED** that CPCs require time to process the outputs of the SC in order to fully explore and understand the advice provided using the MSE process. To facilitate this, the TCMP **RECOMMENDED** that the Commission endorse holding a virtual TCMP meeting early each year with a view to discuss or narrow down the alternative candidate MPs proposed by the SC, providing sufficient time for CPCs to discuss the outputs of the SC and consider developing proposals based on them. The TCMP would then meet again physically prior to the Commission.*

*(Para 47) The Commission **SUPPORTED** the important work conducted by the TCMP and **ENDORSED** the Recommendation to hold a virtual meeting early in the year. This would be included in the schedule of meetings from 2023.”*
6. The WPM(MSE) **NOTED** the Commission's inclusion of an additional TCMP meeting early each year, and although this additional session of the TCMP has not taken place in 2023 (see paragraph 9 below), it **RECOMMENDED** that it would be necessary in 2024 to present the final advice regarding SKJ for the Commissions consideration.

### 2.2 Review outcomes of WPM, WPB, WPTT and SC in 2022

7. The WPM(MSE) **NOTED** a brief summary provided by the Chair on the discussions held at the 2022 sessions of the WPM, WPB, WPTT and SC all of which had taken place since the last WPM MSE Task Force meeting. The Secretariat summarised the information related to MSE contained in the documents, IOTC-2022-WPM13-R, IOTC-2022-WPB20-R, IOTC-2022-WPTT24-R, and IOTC-2022-SC25-R.
8. The WPM(MSE) **NOTED** that the application of exceptional circumstances for the Bigeye Tuna MP in 2022 were discussed extensively at WPM8 and WPTT24 and evidence reviewed included new biological parameters and fishery operations, input data, and a comparison of the estimated population trend in the assessment with operating models. The WPM(MSE) were **INFORMED** that the SC **AGREED** that the review of evidence for exceptional circumstances did not identify any reasons to change the advice on the TAC.
9. The WPM(MSE) **NOTED** the following recommendations from the SC report (IOTC-2022-SC25-R):
  - (SC25.18 (para. 98) The SC **NOTED** that the application of the bigeye management procedure resulted in a recommended TAC of 80,583 t per year for 2024 and 2025, which requires a 15% catch reduction from the 2021 catch level. The SC **RECOMMENDED** that the Commission endorse the calculated TAC for 2024 and 2025.

- SC25.21 (para. 122) The SC **QUERIED** whether it would be necessary to hold a virtual TCMP meeting early in the year if no MPs are considered ready for presentation to the TCMP that particular year. The SC **RECOMMENDED** that there is no need to organize a virtual TCMP as no candidate MPs will be ready for consideration for adoption in 2023.

10. The WPM(MSE) **NOTED** that care should be taken when presenting the outputs of the MSE. Small errors such as insufficient decimal places in the estimations as well as errors in parameter signs can cause confusion and prevent replication of the results.

### 3. STATUS OF WORK ON SKIPJACK OMs AND MPs

#### 3.1 Review progress and difficulties

11. The WPM(MSE) **NOTED** the presentation of the work currently being carried out on MSE for skipjack tuna, summarized by the authors as follows:

*“The objective of this work is to develop a Management Procedure (MP) for Indian Ocean Skipjack tuna (SKJ), which includes specification of the data inputs, harvest control rule (HCR) and management outputs, and that has been fully tested using an appropriate simulation framework.*

*A simulation framework has been proposed to the Working Party on Methods (WPM; Edwards, 2020, IOTC, 2020a) and the Technical Committee on Management Procedures (TCMP; Edwards, 2021b, IOTC, 2021c), and evaluations of an empirical MP were delivered to the WPM (Edwards, 2021a), and the MSE Task Force (Edwards, 2022a). At the TCMP in 2022, a preliminary set of MPs was presented (Edwards, 2022b) and received feedback from the TCMP (IOTC, 2022b). In particular:*

*67. The TCMP NOTED that previously, a request had been made to the developer to remove positive bias in catches and therefore implementation error had been removed from the OM tuning. The TCMP AGREED that it is best practice to include implementation error and this option should once again be explored in the tuning. In addition, the tuning should continue to use the three options for being in the green zone of 50%, 60% and 70%.*

*In response, candidate MPs were tuned to the 50%, 60% and 70% turning criteria under the assumption of constant, positive implementation error values of 10%, 20%, 30% and 40%. These results were presented by Edwards (2022c) to the WPM (IOTC, 2022a). The current work is a first step towards testing robustness of these candidate MPs to recruitment failure, and ability of the MPs to recover the fishery.”*

12. The WPM(MSE) **DISCUSSED** the use of BMSY and B40% reference points to evaluate stock status. Previously B40% had been used as a proxy for BMSY. However, the WPM(MSE) **AGREED** that BMSY should be distinguished from B40%, and that the latter should be referred to as the “target” reference point. When tuning the MP the developers tuned to the probability of being in the “target green” quadrant, rather than the “Kobe green” quadrant, because the Kobe plot is defined using MSY reference points. The WPM(MSE) **SUGGESTED** that (i) the terminology in the report should therefore be updated to reflect this (ii) Colours should also be updated in figures of the quadrant probabilities, with a non-Kobe colour scheme adopted and (iii) stock status with reference to BMSY should be included in the diagnostics table.
13. The WPM(MSE) **DISCUSSED** the labelling of MPs. The WPM(MSE) **AGREED** that labels should reflect both the MP structure (i.e. the choice of Cmax) and also the tuning criteria used in the design. This will avoid MP labels being repeated, when the same Cmax value is used in MPs tuned under different implementation error scenarios.
14. With regards to the robustness test, the WPM(MSE) **NOTED** that recruitment failure happens one year before the TAC is set. The MP does not anticipate the drop in the SSB, because of a one-year lag in recruitment to the fishery, and therefore overestimates the catch when setting the TAC for 2024 – 2026 (the first implementation period). The OM does not limit changes in the fishing capacity, and the TAC is caught in the first year of implementation (2024) despite the drop in SSB. This is associated with a high fishing mortality necessary to reach the TAC, which may not be realistic, and leads to collapse of the stock. In subsequent years (2025 – 2026), the catch is limited by the availability of fish, and the catch is low despite the high TAC. The MP sets the TAC at a lower value for the 2027-2029 period, which allows the stock to recover. The current set up for the robustness

trial would therefore represent an extreme scenario of engineered stock collapse. The WPM(MSE) **NOTED** that MPs seem to cope with this scenario and achieve the management objectives.

15. The WPM(MSE) **NOTED** that the results suggest that the MPs with 20% implementation error appear to work better (higher probability of reaching the TRP) than those with less error. The developer noted that this needs further verification. The WPM(MSE) **AGREED** that it is best to apply the same catch for all the scenarios for the 2021-2023 period based on the difference between the current TAC and the catch observed in 2021
16. The WPM(MSE) **NOTED** that the MP works when recruitment fails by reducing the TAC to the lowest possible value (Cmin) and does not have a stability clause to limit the TAC change between management periods. The WPM(MSE) further **NOTED** that the large drop in TAC may cause some confusion during the TCMP and it will be necessary to emphasise that this is a scenario in which stock collapse has been deliberately engineered and is not necessarily realistic.
17. The WPM(MSE) **REQUESTED** that the developer simulate recruitment failure using a lower quantile of the recruitment error distribution estimated during the fitting period. Recruitment failure should be applied for two years in a row (2023-24) instead of the current three (2023-2025).
18. The WPM(MSE) **NOTED** that the potential observation of a sudden drop of CPUE could also be part of the Exceptional Circumstances protocol and halt the TAC set within that management period.
19. The WPM(MSE) **AGREED** that an initial 15% catch stability limit should be trialled (in line with other stocks) but to request feedback from the TCMP on the definition of the stability clause for the MP (maximum percentage of change of TAC between management periods and level of catch rate that would invalidate the stability clause). The TCMP report of 2021 (paragraphs 63 and 64) provides information on alternatives for stability clauses in the IOTC.
20. The WPM(MSE) **DISCUSSED** the need to define when an MP is considered robust. For example, the robustness tests showed a relatively large probability of being below the safety limit (<Blim). The WPM(MSE) **NOTED** that the large probability of breaching the safety limit would be due to the extreme robustness scenario assumptions.
21. The WPM(MSE) **NOTED** that there is a need to specify the CPUE standardization process (cycle, periods, methods) to be included in the MSE simulations. For this, a conversation with the developers of the CPUE series will be necessary. This will help to understand the uncertainties in the CPUE generation process, and also allow the developer to include an appropriate lag in the MP implementation cycle. The WPM(MSE) **REQUESTED** the developer to attend the WPTT Data Preparatory meeting to contribute to the CPUE discussion.
22. The WPM(MSE) **DISCUSSED** different options to evaluate the impact of over-catch in the MSE simulations. The agreed option would be to tune MPs without implementation error and to incorporate the implementation error in the OM projections. Then, the impact of the implementation error on MP performance could be evaluated. The WPM(MSE) **NOTED** that this work was done in the past and that these simulations could be compared to the ones presented in this meeting with the implementation error included in the tuning. The WPM(MSE) also **NOTED** that if there was a formal request from the TCMP to show the performance of the MPs tuned to the implementation error (as requested by the TCMP in 2022), these could be shown as well.

### 3.2 Future Work

23. The WPM(MSE) made the following **SUGGESTIONS** to the developer:
  - The developer should explore an option to update the OM with a limit to the possible inter-annual change in the fishing mortality, to reflect limitations in the possible annual changes in fishing effort (for robustness trials only).
  - A 15% symmetrical change in the TAC cap should be applied.
  - More realistic recruitment scenarios should be tested using a lower quantile of the recruitment residuals (estimated during the assessment) applied to the 2023-2024 period.
  - MPs should be tuned assuming a 0% implementation error, and then evaluated using 0% - 40% over-catch during the projection.

- It should be explained that an over-catch beyond the values tested by the MP will invoke exceptional circumstances. A protocol for the management decisions for exceptional circumstances should be developed.
- The developer will attend the WPTT Data Preparatory meeting to discuss the CPUE standardization process (cycle, periods, methods) to be included in the MSE simulations, understand the uncertainties in the CPUE generation process, and analyze an appropriate time lag in the MP implementation cycle.
- The developer in consultation with the WPM should determine if it is necessary to update the OM based on the new SKJ assessment due to be carried out in 2023.

## 4. STATUS OF WORK ON ALBACORE OMs AND MPs

### 4.1 Review progress and difficulties

24. The WPM(MSE) **NOTED** the presentation of paper IOTC-2023-WPM14(MSE)-04 which explores an Approximate Bayesian Computation approach for conditioning the operating models for Indian Ocean Albacore tuna, including the following summary provided by the authors.

*“For the current suite of IOTC MSE work, the general approach to conditioning the required set of Operating Models (OMs) has been to use the species-specific stock assessment model structure as the basis for the OMs. A grid of model runs, formulated using a set of alternative assumptions and inputs, is constructed based on the base case assessment model. In Hillary et al. (2021) an alternate, complementary approach was outlined where, instead of the assessment being the basis for conditioning, a suite of possible prior states of historical dynamics and current status are defined. The available, but mostly the more contemporary, data are included within an estimation scheme built on emerging Approximate Bayesian Computation (ABC) and Synthetic Likelihood (SL) concepts. The aim is to generate a distribution of current abundance, mortality and status that is consistent with both the available data and the suite of possible prior states of nature defined beforehand. This can then be used to initialise the OMs used to project the stock into the future and test the candidate MPs.*

*In this paper we parameterise a real world example using Indian Ocean Albacore tuna that mirrors (biologically and structurally) the most recent stock assessment, utilises length composition and longline CPUE data, and is able to explore a wide range of stock status prior hypotheses, many of them built on information from the results of the stock assessment.”*

25. The WPM(MSE) **NOTED** that priors for relative SSB depletion and SBMSY ratios were used as the status variables in the example OM, but priors for FMSY status were not used due to the difficulty in determining how SS3 estimates annual FMSY when there is strong seasonal variation in the relative F estimates.
26. The WPM(MSE) **NOTED** that there is more than one model in the current albacore assessment, but that the example OM presented is based on the diagnostic case.
27. The WPM(MSE) **NOTED** that the most recent assessment fits to the disaggregated length-frequency data and the seasonal CPUE data from the longline fleets. However, the example OM aggregates the size data across years and seasons and fits to a mean size frequency data set per fishery to obtain a representative selectivity relationship for each fishery.
28. The WPM(MSE) **NOTED** the flexibility in the ABC approach for conditioning OMs in that it is possible to either impose values or set priors for status and other model parameters. It is also possible to use different status metrics (e.g. MSY or depletion-based) for the initial and terminal stock status.
29. The WPM(MSE) **NOTED** the strong influence that size data can have on the estimation of unfished recruitment (R0) and the importance of evaluating whether variability in size data is driven by population dynamics or sampling variability. The WPM(MSE) further **NOTED** that simply down-weighting size data that are not fitted too well by the model does not necessarily solve the problem.
30. The WPM(MSE) **NOTED** that an advantage of using the ABC approach is that it is possible to build distributions for all model parameters (as opposed to the gridded factorial design approach in the stock assessment), and that

parameters can be modelled with correlated joint distributions, which can reduce the number of unrealistic combinations of parameter estimates that make it through to the final OM grid.

31. The WPM(MSE) **NOTED** that the structure of the projection models will not be changed from the previous configuration, and that MCMC sampling of the OMs will be used to generate parameter values for the projections.
32. The WPM(MSE) **NOTED** that the gridded factorial design approach used to condition previous OMs for albacore is currently not being updated with information from the most recent assessment, and is not currently being used to evaluate MPs.
33. The WPM(MSE) **NOTED** that there was no observed build-up of older age classes in the model (i.e. cryptic biomass) that might be expected if there was a problem with using a log double normal selectivity function. But it may be possible to simplify selectivity to a logistic function for some fleets where the selectivity pattern appears more logistic in shape.
34. The WPM(MSE) **NOTED** that it may be better to use depletion rather MSY ratios for priors when tuning the albacore OMs to avoid any stock status implications when communicating the results. However, the WPM(MSE) also **NOTED** that there may be some circumstances where it might be more informative to use MSY ratios which vary more than depletion across different values of steepness and M.
35. The WPM(MSE) **NOTED** that the new ABC approach for conditioning the OMs may result in a narrower range of OMs than the previous grid approach, but this would be best tested with a direct comparison of both approaches. The WPM(MSE) further **NOTED** that a narrower range of OMs does not necessarily mean a more plausible range, but that the ABC approach is more internally coherent than the previous grid approach.
36. The WPM(MSE) **NOTED** the situation where implausible combinations of parameters can produce sensible outcomes and be retained in the OM. Examining projections can identify some of these situations (e.g. when the model runs out of fish). The WPM(MSE) **NOTED** that it will be important that developers explain clearly why particular combinations of parameters are retained in the OMs.
37. The WPM(MSE) **NOTED** that all the standard Bayesian statistics used to evaluate model convergence can be applied to the ABC approach.
38. The WPM(MSE) **NOTED** that the variability in CPUE data among fleets indicates that it will be difficult to use an 'areas as fleets' approach, and that there might be a need to consider an explicit spatial model.
39. The WPM(MSE) **NOTED** that the current example OM is sex-structured in an attempt to mirror the current assessment. However, given there is minimal difference in growth between sexes, it might be appropriate to simplify the model by combining sexes.
40. The WPM(MSE) **NOTED** that constant values of M across all ages (ranging from 0.2 to 0.35) are currently used in the example OM (as opposed to age-specific values) because previous model grids have indicated that imposing higher mortality on younger individuals that are not selected by the gear has no appreciable effect on model outputs.
41. The WPM(MSE) **NOTED** the need to define joint prior distributions for some model parameters and **AGREED** that this was particularly important for steepness and mortality which have the largest influence on stock status.
42. The WPM(MSE) **NOTED** that the value of sigmaR (0.3) in the example OM is relatively low and that other values should be explored.
43. The WPM(MSE) **NOTED** that a 1% annual increase in catchability is currently used in the example OM and that it would be useful to explore an option with no increase in catchability.
44. The WPM(MSE) **NOTED** that the start year for the OM could be 5 years earlier (i.e., 1995) to capture the relatively high CPUE observed in 2020.

## 4.2 Future Work

45. The WPM(MSE) **NOTED** that the developers plan to pursue development of the model validation process for the ABC approach to align with principles of previous OMs-MSE and aim to present a full albacore OM that can evaluate candidate MPs to the WPM in October 2023.

## 5. STATUS OF WORK ON SWORDFISH OMs AND MPs

### 5.1 Review progress and difficulties

46. The WPM(MSE) **NOTED** the presentation of the work currently being carried out on MSE for swordfish, contained in document IOTC-2023-WPM14(MSE)-05, and summarized by the authors as follows:

*“A brief summary of current status and recent developments on the work for an MSE analysis for Indian ocean swordfish is presented here. An updated uncertainty grid for the OM construction, new proposal for a model free MP and the implementation of a surplus production model for a model-based MP need to be discussed by MSE task force of WPM to guide the next steps of work for this species.”*

47. The WPM(MSE) **THANKED** the developers for this update and **REQUESTED** that they present the completed analysis to the upcoming TCMP.
48. The WPM(MSE) **NOTED** the updated OM for swordfish and the fact that it had been presented to and discussed by the experts on the stock at the last session of WPB. The WPM(MSE) **NOTED** that the smaller grid has led to a higher model acceptance rate.
49. The WPM(MSE) **NOTED** the presented runs for both model-free and model-based MPs, which in both cases were made to achieve the requested management objectives (50, 60 and 70% probability of the stock being into the Kobe green in the 2024 to 2038 period). The WPM(MSE) **NOTED** that JABBA has been used as the surplus-production model providing information on stock status on the model-based MP.
50. The WPM(MSE) **NOTED** the current configuration of JABBA and **SUGGESTED** a number of possible alternatives with regards to the estimation of model and process error parameters that could be used in the future. The WPM(MSE) also **SUGGESTED** employing in the hockey-stick HCR a trigger point lower than the current 40% of B0. This change could lead to higher average catches at the expense of greater catch variability, and it is an important trade-off to explore.
51. The WPM(MSE) **NOTED** the analysis on the reactivity of the model-free MP to a range of possible values for its parameters. The CPUE-based HCR in this type of MP contains four parameters (k1 to k4) that control the intensity and symmetry of its response to changes in the stock size index. A series of MP runs were carried out using different values for the four parameters over a reduced number of OM iterations.
52. The WPM(MSE) **NOTED** that MPs with low reactivity and symmetric response appear to be able to achieve the tuning management objectives, while leading to higher catch and lower catch variability than alternative configurations of the MP. The WPM(MSE) **SUGGESTED** using the results of this analysis to set the values for the un-tuned MP parameters.
53. The WPM(MSE) **NOTED** that a robustness test was carried out to explore the ability of the model-free MP, tuned to the three management objectives from the current positive stock status using the low reactivity settings, to react to a negative event, such as a series of low recruitments. The tested scenario considered recruitment to fall to 10% of expected levels over a four-year period.
54. The WPM(MSE) **AGREED** that this is an unlikely scenario, but one that is a valid test of MP robustness under a particularly extreme event. The WPM(MSE) **NOTED** that the effect of such disruption in the stock dynamics appears to be small, given the life span of the species.
55. The WPM(MSE) **NOTED** the discussion on the choice of tuning period and length of projection. The difference between stock status at the start of the simulations and that to be achieved with tuning, has an effect on how the MP will behave after the tuning period. The WPM(MSE) **AGREED** that the main consideration when analyzing MP performance relates to the period over which the MP is likely to be applied, 10 to 15 years, but that any kind of behaviour, in which the stock might be brought to lower levels than desirable in order to achieve the tuning

objective, should be identified after that period. The WPM(MSE) **NOTED** that the long-term performance of the MPs is reported in the final tables contained in the MSE presentation guidelines.

## 5.2 Future Work

56. The WPM(MSE) **NOTED** that the presented analysis forms a sufficient basis for the TCMP to explore possible options for an MP for this stock to be discussed and adopted in the near future.
57. The WPM(MSE) **NOTED** that the model-free MP has been run without any limits of TAC changes, and so it **REQUESTED** the developers to re-tune the model-free MPs with the addition of a 15% limit in TAC changes every three years, as requested by TCMP.
58. The WPM(MSE) **SUGGESTED** the developers to take on some of the issues discussed and make the necessary changes to the code, so that a final set of runs could be presented to WPM in October 2023.

## 6. STATUS OF WORK ON YELLOWFIN OMs AND MPs

### 6.1 Review progress and difficulties

59. The WPM(MSE) **NOTED** that the yellowfin tuna MSE has not made any further progress and that the modelers are examining alternative methods of conditioning the OM for this species. More specifically, the Approximate Bayesian Computation (ABC) paradigm is being investigated and has shown some encouraging results to reduce reliance on stock assessments model grid for OM conditioning and uncertainty characterisations (see Section 8 for its application on albacore tuna). The ABC approach aims to provide a flexible statistical framework to condition historical data and to incorporate more robust prior constraints on key state variables.
60. The WPM(MSE) **NOTED** that the yellowfin stock assessment underwent an external review in February. The WPM(MSE) was briefed on some of the issues with the yellowfin assessment models that had been brought up at the review workshop and **NOTED** that the full review report would be made available for the WPTT and the SC to review and discuss. The review workshop offers some recommendations for how to improve the yellowfin stock assessment, which can also be considered and accommodated for the ongoing development of the yellowfin MSE.

## 7. STATUS OF BIGEYE MP

### 7.1 Work in support of Res 22/03

61. The WPM(MSE) **NOTED** that the SC, through the Working Party on Methods and Working Party on Tropical Tunas, ran the MP for bigeye tuna (as per Resolution 22/03) in 2022 to recommend a TAC for 2024 and 2025. The SC also examined the exceptional circumstances, but no evidence of such conditions was found. The TAC was recommended to the Commission for consideration and endorsement.
62. The WPM(MSE) **AGREED** that resources should be set aside in future iterations of running the MP to continue monitoring and assessing exceptional circumstances that could potentially render the MP inappropriate.

## 8. GENERAL DISCUSSION ON OMs AND MPs

### 8.1 Consideration of multi-species OMs/MPs

63. The WPM(MSE) **NOTED** that there is a multispecies MSE initiative for Atlantic tropical tunas which is based on FLBEIA (García et al, 2012) a MSE simulation framework applied to ICES demersal fisheries. The WPM(MSE) also **NOTED** the MSE work for tropical tunas developed in the WCPFC, which evaluates the impact of achieving a TRP for one stock on the exploitation of the other two stocks.

### 8.2 BET external peer-review

64. The WPM(MSE) **NOTED** that the Terms of Reference for an external peer review of the bigeye tuna MP are reported in the 2021 SC report. The WPM(MSE) **NOTED** that funding had been secured and a suitable consultant



identified to complete the review. The consultant will be available to commence the review after July 2023, and it is anticipated that the results will be presented to the WPM and WPTT in 2023 or 2024.

## 9. PREPARATION OF TCMP06 AND COMMISSION (S27)

### 9.1 Agenda for TCMP06

65. The WPM(MSE) **DISCUSSED** the agenda for the TCMP06 and **AGREED** to the version provided in [Appendix IV](#) of this report.

### 9.2 Organization, tasks and responsibilities

66. The WPM(MSE) **DISCUSSED** the organization of TCMP06 meeting with associated tasks and responsibilities prior to and during the meeting and **AGREED** that the Skipjack and Swordfish updates would take priority in 2023.

### 9.3 Presentations of results

67. The WPM(MSE) **DISCUSSED** the contents of the presentations for the various species. The WPM(MSE) **SUGGESTED** that the presentations should consist of the standard agreed format of MP performance summary graphics (time-aggregated performance statistics and time series plots), tables and document as presented to the TCMP03, TCMP04 and TCMP05.
68. The WPM(MSE) **NOTED** that the TCMP should be advised on the status of funding support (e.g. tentative CPC funds and/or Commission budget).

### 9.4 Capacity building on MSE at IOTC

69. The WPM(MSE) **NOTED** the following discussions held during the Commission in 2022 (IOTC-2022-S26-R):
- “(Para 49) The Commission ACKNOWLEDGED an offer by the PEW Charitable Trusts to support capacity building workshops and activities for MSE. The Commission REQUESTED the Secretariat to liaise with PEW to coordinate these activities.”*
- (Para 83) The Commission ACKNOWLEDGED further offers to support capacity building workshops and activities for MSE from WWF and ISSF (Refer also to paragraph 49).”*
70. The WPM(MSE) **NOTED** that the Secretariat had been in contact with PEW and an MSE capacity building workshop for coastal states has been planned for late September.
71. The WPM(MSE) **NOTED** that the ABNJ project (phase II) also included an MSE component, and that educational tools and workshops were being planned under that project that would benefit IOTC members.

## 10. OTHER BUSINESS

### 10.1 Call for Chairs of the WPM in 2023

72. The WPM(MSE) were **INFORMED** that the current chair of the WPM would finish their second term in 2023 and that a new chair would be required. The WPM(MSE) were **REMINDING** that the WPM also has no vice-chair to take over this role.

## 11. ADOPTION OF REPORT

73. The WPM(MSE) **NOTED** that the report would be adopted via correspondence.

## APPENDIX I

### LIST OF PARTICIPANTS

#### Chairperson

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#### Vice Chairperson

Vacant

#### Other Participants

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## APPENDIX II

### MEETING AGENDA

**Date:** 28-31 March 2023

**Location:** Online

**Platform:** MS Teams

**Time:** 12:00 – 14:00 daily (Seychelles time)

**Chair:** Hilario Murua (ISSF); **Vice-chair:** Vacant

### DRAFT AGENDA

- 1. Opening and adoption of agenda**
- 2. Review of MP process in IOTC**
  - 2.1. Review outcomes of TCMP05 and COM (S26) in 2022
  - 2.2. Review outcomes of WPM, WPTT and SC in 2022
  - 2.3. Process of MSE development, discussion and adoption at IOTC
- 3. Status of work on Skipjack OMs and MPs**
  - 3.1. Review progress and difficulties
  - 3.2. Future work and suitability of MP for management advice in 2023
- 4. Status of work on Albacore OMs and MPs**
  - 4.1. Review progress and difficulties
  - 4.2. Future work
- 5. Status of work on Swordfish OMs and MPs**
  - 5.1. Review progress and difficulties
  - 5.2. Future work
- 6. Status of work on Yellowfin OMs and MPs**
  - 6.1. Review progress and difficulties
  - 6.2. Future work
- 7. Status of Bigeye MP**
  - 7.1. Work in support of Res 22/03
  - 7.2. Future work
- 8. General discussion on OMs and MPs**
  - 8.1. Alternative OM conditioning approaches
  - 8.2. Consideration of multi-species OMs/MPs
  - 8.3. Exceptional circumstances
  - 8.4. Internal peer-review and BET external peer-review
  - 8.5. Workplan and roadmap 2023-2025
  - 8.6. Other issues
- 9. Preparation of TCMP06 and Commission (S27)**
  - 9.1. Agenda for TCMP06
  - 9.2. Organization, tasks and responsibilities
  - 9.3. Presentations of results
  - 9.4. Capacity building on MSE at IOTC
- 10. Other issues for WPM 2023**
  - 10.1. Stock status guidance
- 11. Other business**
  - 11.1. Call for Chairs of the WPM in 2023
- 12. Adoption of Report**

**APPENDIX III**  
**LIST OF DOCUMENTS**

<b>Document</b>	<b>Title</b>
IOTC–2023–WPM14(MSE)–01a	Agenda of the 14th Working Party on Methods Management Strategy Evaluation Task Force
IOTC–2023–WPM14(MSE)–03	Initial robustness trial of empirical MPs for Indian Ocean skipjack tuna (Edwards C)
IOTC–2023–WPM14(MSE)–04	Exploring the ABC approach for IOTC Albacore OM conditioning (Hillary R, Mosqueira I)
IOTC–2023–WPM14(MSE)–05	Updates on development of MSE analyses for Indian Ocean swordfish (Brunel T, Mosqueira I)

**APPENDIX IV****PROPOSED AGENDA FOR THE TECHNICAL COMMITTEE ON MANAGEMENT PROCEDURES (TCMP)****Date:** 5-6 May 2023**Location:** InterContinental Mauritius Resort Balaclava, Mauritius (Hybrid)**Co-Chairs:** Ms. Riley Kim Jung-re (Commission Chair) and Dr. Toshihide Kitakado (SC Chair)**1. OPENING OF THE SESSION AND ARRANGEMENTS (Co-Chairs)****2. ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION (Co-Chairs)****3. ADMISSION OF OBSERVERS (Co-Chairs)****4. DECISIONS OF THE COMMISSION RELATED TO THE WORK OF THE TECHNICAL COMMITTEE ON MANAGEMENT PROCEDURES (IOTC Secretariat)**

- 4.1 Resolution 16/09 – Terms of Reference
- 4.2 Outcomes of the 5<sup>th</sup> Session of TCMP
- 4.3 Outcomes of the 26<sup>th</sup> Session of the Commission
- 4.4 Outcomes of the 25<sup>th</sup> Session of the Scientific Committee

**5. INTRODUCTION TO MSE****6 STATUS OF THE MANAGEMENT STRATEGY EVALUATION/OPERATING MODELS AND ACTIONS NEEDED FOR ADOPTION (Developers)**

- 6.1 Skipjack tuna (Charlie Edwards)
- 6.2 Swordfish (Thomas Brunel)
- 6.3 Albacore tuna (Iago Mosqueira)
- 6.4 Yellowfin tunas (Rich Hillary)
- 6.5 General Issues
  - 6.5.1 Exceptional circumstances
  - 6.5.2 MP implementation, actions and regular implementation review

**7 ACTION REQUIRED FOR RESOLUTION 22/03 *On a Management Procedure for bigeye tuna*****8 FUTURE DIRECTION OF THE TECHNICAL COMMITTEE ON MANAGEMENT PROCEDURES (Co-Chairs)**

- 8.1 Workplan
  - 8.1.1 New timelines
  - 8.1.2 Budget and resources needed for technical developments
  - 8.1.3 External review
- 8.2 Priorities
- 8.3 Process and future meetings of TCMP

**9 ADOPTION OF REPORT (Co-chairs)**

**APPENDIX V****CONSOLIDATED RECOMMENDATIONS OF THE 14<sup>TH</sup> SESSION OF THE WORKING PARTY ON METHODS  
(MANAGEMENT STRATEGY EVALUATION TASK FORCE)**

***NOTE: APPENDIX REFERENCES REFER TO THE REPORT OF THE 14<sup>TH</sup> SESSION OF THE WORKING PARTY ON METHODS (MANAGEMENT STRATEGY EVALUATION TASK FORCE) (IOTC–2023–WPM14(MSE)–R)***

WPM(MSE)14.01: The WPM(MSE) **NOTED** the Commission's inclusion of an additional TCMP meeting early each year, and although this additional session of the TCMP has not taken place in 2023 (see paragraph 9 below), it **RECOMMENDED** that it would be necessary in 2024 to present the final advice regarding SKJ for the Commissions consideration (Para 6).